

Citation for published version:

Novikova, J, Watts, L & Bryson, JJ 2014, 'The role of emotions in inter-action selection', *Interaction Studies*, vol. 15, no. 2, pp. 216-223.

Publication date:

2014

Document Version

Early version, also known as pre-print

[Link to publication](#)

University of Bath

Alternative formats

If you require this document in an alternative format, please contact:
openaccess@bath.ac.uk

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

The Role of Emotions in Inter-Action Selection

Jekaterina Novikova, Leon Watts, Joanna J. Bryson

University of Bath, UK

Keywords: human-robot interaction; artificial emotions; social behaviour

Faragó et al (hereafter FMS&G) draw attention to an important issue for researchers of human-robot interaction (HRI): can we conceive a scheme for making social robot behaviour both comprehensible and appropriate in human social settings? We agree with the authors concerning the potential utility of drawing on the example of domestic animals — particularly dogs, the species with which we have the longest history of co-evolution as social interactors. Here we seek to extend from the authors emphasis on the detail of species-specific interaction to a general blueprint for robot action selection. We particularly emphasise the integral role of emotions in facilitating social inter-action selection as social signals of internal agent states that are relevant to joint action.

Our research questions concern the general abilities of artificial agents, particularly robots, to express their current, transient internal states in ways that people find comprehensible and acceptable. This requires that researchers consider not only the potential communicative value of a social signal but also the validity or utility of the internal state which it describes. Were it the case that the role of the human was to correctly identify a signal, as a passive observer of the robot, it would be a simple matter to construct a repertoire of discriminable social actions. However, this leads us to an important issue in HRI research not emphasised by FMS&G : the nature of interaction itself as a concept that requires simultaneous consideration of the actors and the acted-upon. Dynamic selection decisions for emotional signalling must depend on considerations that span human and robot: a question of emotional inter-action selection.

1 Interaction must support the construction and refinement of human mental models

Interaction differs from individual action in that it requires consideration of at least two entities: the actor and the acted-upon. An action can be described uniquely (if rather unsatisfactorily) in terms of the behaviour of a particular actor in isolation. An attempt to describe interaction in such a way is meaningless. Since the Norman [16] Theory of Action, human-computer interactions are typically understood as a cycle of: goal-directed plan formulation based on an internal model of the effects of a particular action on an object or system, execution of the plans, observation of the result, and reformulation. Reformulation may include

31 updating the agents internal model, alteration of the plan, or alteration of the internal model, and may be
32 conducted on-the-fly to compensate for low-level execution errors [15]. In the human case, the internal
33 model is typically referred to as a ‘mental model’ of a system with which a person interacts — a model
34 that encapsulates a person’s own understanding of that system and their capabilities with respect to it.
35 As humans automatically ascribe agency to robots, any robot’s signalling mechanism will naturally be
36 treated as indicative of its internal functioning, and human ‘mental models’ of the robot will be constructed
37 accordingly. As a result, a signalling system that is intended only to improve the superficial acceptability of
38 a robot will almost certainly not succeed. It is necessary to consider how one might engineer a meaningful
39 relationship between any robots internal state and the social signals it produces.

40 As FMS&G correctly state, social communication is typically identified with affective states. It is less
41 clear that the authors recognise that many emotional states are not simply broadcast but are often directed at
42 other agents in particular. Social communication may be exclusively about interpersonal affective attitudes
43 (John smiles at Jane → John likes Jane) or combined with other social significance (Jane smiles at and mo-
44 tions John towards a café → Jane likes John and proposes that they eat together). In the case of social robots,
45 we can expect mental model generation to be facilitated by the human tendency to anthropomorphize any
46 system with uninspectable internal states. McCarthy [12] famously argued that more humanly manageable
47 interactions result from the ascription of mental qualities to machines, especially beliefs, knowledge, inten-
48 tions, and wants. It is quite simply easier for people to understand machines in these terms than in terms
49 of their underlying architecture or functionality. Consequently, people routinely attribute affective states to
50 machines as part of a “social actor” strategy for informally modelling hidden processes [19]. Moreover,
51 people anticipate that such objects or agents will respond to them in emotional ways [4].

52 **2 The Value of Emotions in Social Human-Robot Interaction**

53 Emotions are not only key to reducing dithering and stabilising individual action selection [3], but also joint
54 inter-action selection. As such, they are an important part of the embodiment necessary for social interaction
55 [5]. For the purpose of this commentary, we refer to emotional action selection as action selection based on
56 temporary but durative state triggered by response to observed events combined with internal motivation. To
57 demonstrate the value of emotions in social HRI we turn to the list of social skills highlighted by FMS&G:
58 cooperating, communicating in different modalities (e.g. visual and acoustic), and showing individuality.
59 We analyse these from a constructivist perspective [6] taking particular account of the role of emotions.

60 **2.1 Emotions in Cooperation**

61 Cooperation is an important social skill, well developed in dogs and certainly useful to implement in social
62 robots. However, it would be difficult to associate cooperation with specific behavioural patterns. Rather

63 than looking for a specific personal behaviour which accompanies human-robot cooperation, it could be
64 more useful to focus on general facilitators of and influences on cooperation.

65 The persuasion approach to cooperation indicates that cooperation increases after the presentation of
66 persuasive messages [22]. Persuasion here is understood as a form of social influence [1], a way to influ-
67 ence people through communication without using force. In order to persuade it is necessary, among other
68 things, to induce or evoke affective states (whether moods, sentiments or emotions). Although effective
69 non-emotional verbal persuasion techniques certainly exist, non-verbal messages are of the greatest impor-
70 tance in persuasion [13], and the emotional component, in at least some conditions, has been shown to have
71 priority over the informational one [14].

72 The topic of affective persuasion is addressed in many disciplines, including marketing, law, and pol-
73 itics, as well as in daily life. However, little work is currently done on the role of emotions in influencing
74 human behaviour in the area of HRI [7].

75 **2.2 Emotions in Communicating Personality and Individuality across Modalities**

76 FMS&G claim that a behaviour of a dog wagging its tail can be considered as a part of a greeting behaviour,
77 “probably signalling the excitement”. The authors also suggest using a general visual signal as “a functional
78 analogue of a tail, with similar dynamics but different appearance and position”. The authors do not explain
79 clearly what is considered to be a primary function of a dogs tail wagging and how different its implemen-
80 tation should be in a robot. Researchers explain a functionality of tail movements both in dogs and in other
81 animals in many different ways, e.g. female goats stimulate sexual interest from a male by wagging a tail
82 [8], a cat’s tail plays an important role in balance during locomotion[25]. Even in dogs, much is communi-
83 cated by the height and stiffness of the tail as well as the rate and enthusiasm of its wagging [11], and even
84 the direction of its wagging [24]. One very important function of tail wagging and many other gestures in
85 dogs is expression of dominance status. To humans they often express subordinate status, a fact that may
86 be critical to the health benefits of canine companions. This important aspect of the relationship between
87 humans and dogs may also explain some of the dogs’ responses to unusual anti-social behaviour by their
88 owners.

89 Obviously (and as the authors imply) robots have very different appearances, and it is unlikely that a
90 direct simulation of dogs’ tail-wagging behavior can help every robots signal excitement (or subordination)
91 in all the situations. On the other hand, it should be possible to express internal state of a robot in an
92 understandable way using a variety of modalities at once — facial expressions (where a face is present)
93 [23], gestures [20], sounds [18], language [10], colour, brightness, and even the overall shape of a robot [9].
94 It is also possible that it is worth adding effectors for communicating emotion, as has been highly successful
95 with the ears of Kismet [2]. Such a multi-modal approach helps to make robots both more acceptable and

more understandable for people, and to make them appear more individual and independent, thus increasing their life-likeness through emerging of a robots ‘personality’.

In consideration of the results FMS&G present, it is also worth remembering first that dogs and owners all have individual personality, and not every dog/owner coupling will be equally well suited. This will also be a consideration for robotics: some owners will want more or less proactive, confident, open or attentive robots. Second, dogs are cognitive systems. Some of their orientation behaviour will not be merely communicative but also triggered by uncertainty in an unusual situation and the need to gather more information. But in closely-coupled agents, every action is also an interaction, so it is not surprising that these functional gestures are perceived as, and therefore serve as, communicative acts as well.

3 Implications for Research on Affective Interactive Robots

We have argued that emotional state and expression are critical to cooperation, including that between person and machine. Our current work approaches this problem by modelling artificial emotions as internal states that factor into a dynamic action selection process. This process couples the synthetic-emotional state with external cues for communicating discrete emotional states to a human before and during the execution of those actions [17]. Artificial emotions can be connected with the goals of the robot and thus can also be triggered by a list of conditions [2]: e.g. the presence of an undesired stimulus, presence of a desired stimulus, a sudden stimulus, or delay in achieving goal. We are currently experimenting with robots’ internal emotional state represented in two dimensions, following a simple valence and arousal model of human affect [23], though we have also explored discrete representations [3]. There are many possible ways to construct such internal state, given a range of sensor input, goal structure and action feedback; our current approach is to change the state dynamically such that it feeds back into the computation of subsequent levels of intensity, treating robot emotion as a latched process that is tied in to its external expression [21]. The key idea following on from the commentary above is that for robot emotion to function effectively in human interactions, it is necessary to consider the internal relevance of the emotional state for the robots operation so that intelligible mappings can be made to a set of signals for the robots human partner. Without this step, the *social* epithet not only has little meaning but emotion is also unlikely to serve interactions well.

4 Conclusions

For robot behaviour to be understandable to people, it must be designed to facilitate the progressive construction of human mental models. All human mental models are constructed through personal interactions with systems, reflecting the characteristics of those systems and beliefs about the utility and dangers that

might arise through their use. Human mental models for social interaction inevitably include social components, especially those that support inferences about internal affective state and external signals and actions. The personal history of an individual with a robot means that each mental model is likely to be unique. Affective states, such as transient emotions, are part-and-parcel of social signalling. An effective design strategy for human-robot interactions depends on an architectural commitment to maintaining robot states that are material to interactions with humans, and that may then be communicated to their human users. The social acceptability of a robot certainly depends on the ability of a person to infer a usable understanding of the robot from its behaviour and signals. However, social acceptability also relates to a broader meaning of social interaction that embeds the rights and responsibilities of social agents towards one another. If signals give rise to unrealistic mental models, they are likely to result in rejection or worse.

References

- [1] André, E., Bevacqua, E., Heylen, D., Niewiadomski, R., Pelachaud, C., Peters, C., Poggi, I., and Rehm, M. (2011). Non-verbal persuasion and communication in an affective agent. In *Emotion-oriented systems*, pages 585–608. Springer.
- [2] Breazeal, C. (2003). Emotion and sociable humanoid robots. *International Journal of Human-Computer Studies*, 59(1):119–155.
- [3] Bryson, J. J. and Tanguy, E. (2010). Simplifying the design of human-like behaviour: Emotions as durative dynamic state for action selection. *International Journal of Synthetic Emotions (IJSE)*, 1(1):30–50.
- [4] Cañamero, L. (2011). Overview of emotion in cognition and action. In *Emotion-Oriented Systems*, pages 419–425. Springer.
- [5] Dautenhahn, K., Ogden, B., and Quick, T. (2002). From embodied to socially embedded agents—implications for interaction-aware robots. *Cognitive Systems Research*, 3(3):397–428.
- [6] Edmonds, B. (1999). Capturing social embeddedness: a constructivist approach. *Adaptive Behavior*, 7(3-4):323–347.
- [7] Gonsior, B., Sosnowski, S., Buß, M., Wollherr, D., and Kuhnlenz, K. (2012). An emotional adaptation approach to increase helpfulness towards a robot. In *Intelligent Robots and Systems (IROS), 2012 IEEE/RSJ International Conference on*, pages 2429–2436. IEEE.
- [8] Haulenbeek, A. M. and Katz, L. S. (2011). Female tail wagging enhances sexual performance in male goats. *Hormones and behavior*, 60(3):244–247.
- [9] Hwang, J., Park, T., and Hwang, W. (2012). The effects of overall robot shape on the emotions invoked in users and the perceived personalities of robot. *Applied ergonomics*.

- [10] Kim, Y., Kwak, S. S., and Kim, M.-S. (2013). Am i acceptable to you? effect of a robot’s verbal language forms on people’s social distance from robots. *Comput. Hum. Behav.*, 29(3):1091–1101.
- [11] Kleiman, D. G. (1967). Some aspects of social behavior in the canidae. *American Zoologist*, 7(2):365–372.
- [12] McCarthy, J. (1979). Ascribing mental qualities to machines.
- [13] Mehrabian, A. (1971). Silent messages.
- [14] Miceli, M., de Rosis, F., and Poggi, I. (2011). Emotion in persuasion from a persuaders perspective: A true marriage between cognition and affect. In *Emotion-Oriented Systems*, pages 527–558. Springer.
- [15] Monk, A. (1998). Cyclic interaction: a unitary approach to intention, action and the environment. *Cognition*, 68(2):95–110.
- [16] Norman, D. A. (1986). Cognitive engineering. *User centered system design*, pages 31–61.
- [17] Novikova, J., Gaudl, S., and Bryson, J. J. (forthcoming). Emotionally driven robot control architecture for human-robot interaction. In *Proceedings of TAROS 2013*.
- [18] Read, R. and Belpaeme, T. (2012). How to use non-linguistic utterances to convey emotion in child-robot interaction. In *Proceedings of the seventh annual ACM/IEEE international conference on Human-Robot Interaction*, pages 219–220. ACM.
- [19] Reeves, B. and Nass, C. (1996). *How people treat computers, television, and new media like real people and places*. CSLI Publications and Cambridge university press.
- [20] Riek, L. D., Rabinowitch, T.-C., Bremner, P., Pipe, A. G., Fraser, M., and Robinson, P. (2010). Cooperative gestures: Effective signaling for humanoid robots. In *Human-Robot Interaction (HRI), 2010 5th ACM/IEEE International Conference on*, pages 61–68. IEEE.
- [21] Rohlfschagen, P. and Bryson, J. J. (2010). Flexible latching: A biologically-inspired mechanism for improving the management of homeostatic goals. *Cognitive Computation*, 2(3):230–241.
- [22] Rosen, J. and Haaga, D. A. (1998). Facilitating cooperation in a social dilemma: A persuasion approach. *The Journal of psychology*, 132(2):143–153.
- [23] Russell, J. A. (1997). Reading emotion from and into faces: resurrecting a dimensional-contextual perspective,. *The psychology of facial expression*, pages 295–320.
- [24] Siniscalchi, M., Lusito, R., Vallortigara, G., and Quaranta, A. (2013). Seeing left- or right-asymmetric tail wagging produces different emotional responses in dogs. *Current Biology*, 23(22):2279–2282.
- [25] Walker, C., Vierck, C. J., and Ritz, L. A. (1998). Balance in the cat: role of the tail and effects of sacrocaudal transection. *Behavioural brain research*, 91(1):41–47.

Authors’ addresses

Jekaterina Novikova

University of Bath

Department of Computer Science
Claverton Down
Bath BA2 7AY
United Kingdom

j.novikova@bath.ac.uk

Leon Watts

University of Bath
Department of Computer Science
Claverton Down
Bath BA2 7AY
United Kingdom

l.watts@bath.ac.uk

Joanna J. Bryson

University of Bath
Department of Computer Science
Claverton Down
Bath BA2 7AY
United Kingdom

j.j.bryson@bath.ac.uk

Author's biography

Jekaterina Novikova received her MSc in Computer Science from the Blekinge Institute of Technology (Sweden), in 2012. She is currently working toward the PhD degree in the Department of Computer Science at the University of Bath (UK), as a member of the Artificial Models of Natural Intelligence (AMONI) Group. Her main research interests include artificial emotions, artificial and natural intelligence and human-robot collaboration.

Leon A. Watts has been researching the effects of technical mediation on human communication since 1992. His work has focused on the derivation of principles for the constitution of computational environments that foster positive and equal contribution to joint activity. He has examined this problem in the context of close personal relationships, dispute resolution, health care, online activism, diplomatic work and, most recently, in human-robot interactions. He takes an interdisciplinary approach to the conceptual and methodological foundations of his efforts, towards a collaborative, social and inclusive version of Englebart's vision for 'augmenting the human intellect'.

Joanna J. Bryson conducts research in two areas: the development of intelligent systems, and the understanding of natural intelligence through scientific simulation. She holds degrees in behavioural science, psychology and artificial intelligence from Chicago (BA), Edinburgh (MSc and MPhil), and MIT (PhD). She is currently a Reader (Associate Professor) at the University of Bath where she leads the Intelligent Systems research group, and a visiting research fellow at the Mannheim Centre for European Social Science Research. She also heads Artificial Models of Natural Intelligence, where she and her colleagues publish in cognitive science, anthropology, behavioural ecology, philosophy, and systems AI.